THE PHYSICS OF…

AP Physics final project description and requirements

DESCRIPTION

Research and design a physics experiment explain the physics of something that interests you

1. Pick a topic
2. Research topic
3. Design experiment and collect data OR Physically Model
4. Write lab report
5. Make summary poster
6. Present Poster During Finals week

YOU WILL HAND IN:

1. Project Proposal 📝
2. Final Lab Report 📄
3. Final Poster 📊

PROJECT REQUIREMENTS:

IDEAS...

- What is the Best Paper Airplane Design?
- Ben Scott Ping Pong Ball Accelerator
- Calculate the Speed of Light using multiple methods (i.e. chocolate bar and microwave)
- Are cars speeding on Maple Hill Road?
- Create a physics simulation with computer code
- Water music - create a musical instrument
- Mentos and Coca-Cola...(remember you need to collect some sort of data!)
- Determine the properties of a water balloon slingshot so that you can hit a target (maybe Mr. Porter?)
- Circuits Experiments
- Arduino Experiments
- Optics Experiments (i.e. Focal Length of lenses...how do glasses work?)
- Recreate an AP Exam Experimental Design Question

IDEAS...

- How does tension affect the speed of mechanical waves through a string?
- Coulomb's Law (why do I get shocked when I touch the doorknob?)
- Physics of the Human Body (i.e. Torque and the Human Knee Joint - Pivot)
- Build Pendulum Wave Machine
- Build a Hoverboard
- Build a Brachistrochrone Track
- Tube resonance lab with tuning forks
- Physics of guitar strings
- Measure the speed of sound with multiple methods
- Calculating Drag Force on Coffee Filters (or inflatable beach ball)
- Physics of a curveball
- Pinhole Camera
- Study a nail bed

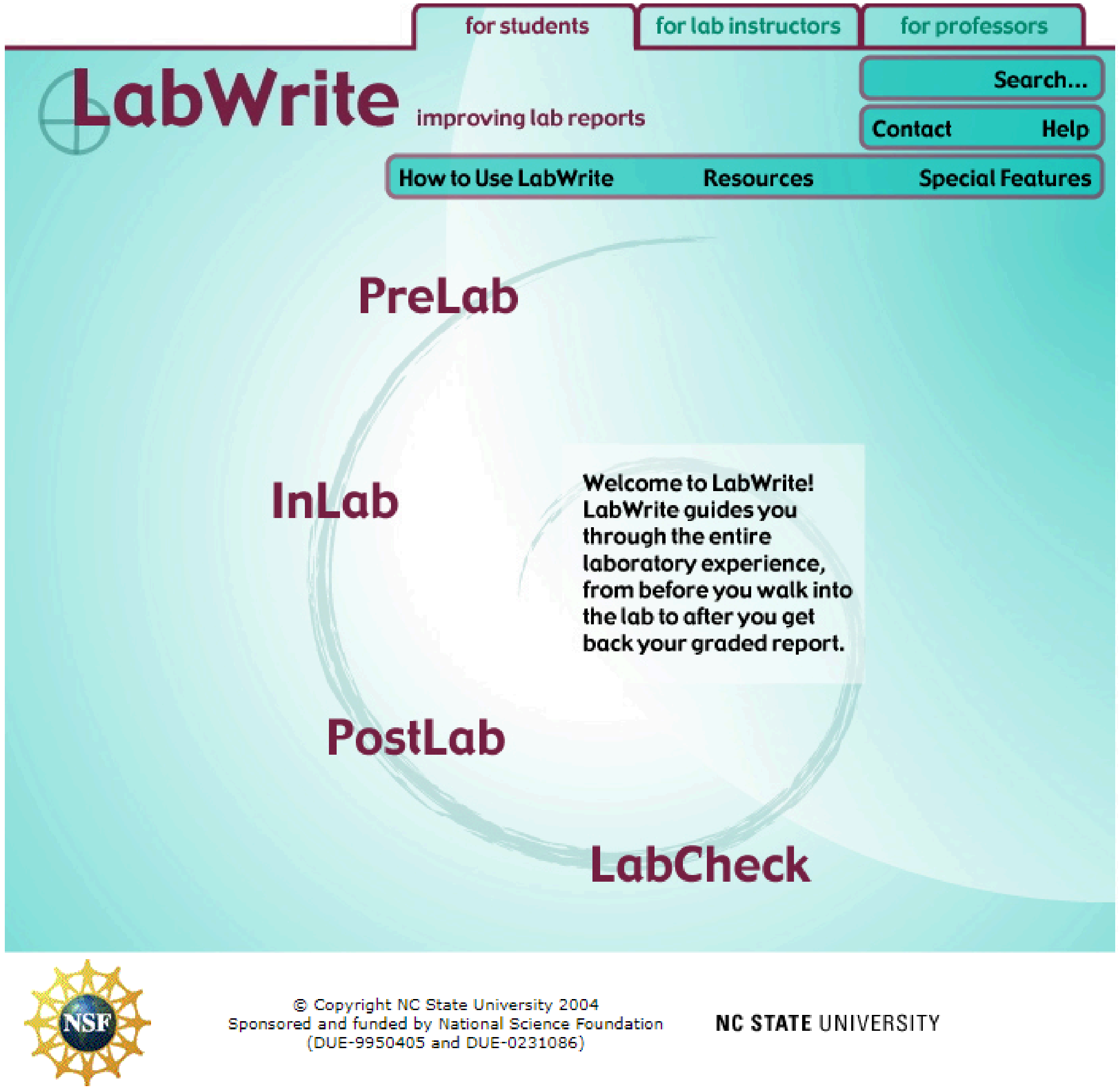
TIMELINE

1. Submit Project Proposal and Prelab Questions (Google Form)
2. Design Experiment
3. Collect Data (follow LabWrite Guide)
4. Analyze Data
5. Create figures for Lab Report
6. Complete Data Review meeting with Porter
7. Write Lab Report in $\LaTeX$ on Overleaf with NCSU LabWrite Process
8. Turn Lab Report into a Poster with $\LaTeX$ and Overleaf

CALENDAR

Monday	Tuesday	Wednesday	Thursday	Friday
5/20 ***Project Proposal***	5/21 No Class	5/22 Experimental Design & Research	5/23 Research/Data Collection	5/24 No School
5/27 No School	5/28 No School	5/29 Data Collection	5/30 Data Collection	5/31 Data Collection
6/3 No Class	6/4 Data Analysis	6/5 Data Analysis/Lab Report	6/6 Lab Report	6/7 ***Lab Report Due***/Start Poster
6/10 No Class	6/11 Poster	6/12 ***Poster Due***	6/13 Something Fun	

NCSU LabWrite



PAPER EXAMPLE

How Does the Mass of a Balloon Affect Its Flight Time?

Emma Dugan, Morgan Delardi, and Grace Barrington*

Our main objective for the lab was to find how mass affects the flight time of a balloon, thinking that a higher mass would have a lower flight time. We filled up two different types of balloons with various masses and used a slingshot, pulling at the same angle and distance, then recorded the time with a stopwatch until they hit the ground. We found that our results did not match with our hypothesis and that mass was negligible. We learned that from the equations we chose to use, our hypothesis should have been correct but from our graphs it showed inaccurate findings to what we had originally thought.

I. INTRODUCTION

The scientific concept applied to this lab is energy, specifically kinetic and elastic potential. The lab is designed to investigate how the flight time of balloons are affected by the scientific concept we chose. The hypothesis for our experiment was the greater mass a balloon had, the quicker the flight time would be. Our independent variable was the mass and our dependent was flight time.

II. METHODS

We used two different kinds of balloons. We had used regular balloons, as well as actual water balloons. The water balloons were thinner, smaller, and popped when they fell on the ground. The regular balloons were thicker, bigger, and did not pop when they fell on the ground. When we filled the balloons, we weighed them on our scale and took note of their mass in our notebook. We used a water balloon sling shot to release the balloons into the air. We had two people stand at equal distance from the pocket of the slingshot, and hold the handle with their arms at a 90 degree angle with their elbow touching their side. One person pulled the pocket down the same distance each time, and another person timed the release to when the balloon hit the ground. We recorded the flight time of the balloons and repeated this for all of our trials. We ran two trials, one with both types of balloons and another with only the water balloons. When we had all of our results, we placed the data into a pivot lab and recorded them in a table. We then put our data into a graph to see our final results.

III. RESULTS

The results of our lab show that the mass of a balloon does not affect the flight time. Our visuals demonstrate that our independent variable, mass, does not affect the dependent variable, time. The graph shows that the slope is almost zero supporting that the mass had no effect. The bar through each point represents the uncertainty in the data. There is a human error in reaction time of .4 seconds, so we took this into account and added it into our data. Looking at these lines, you can see that there is a place where all of the data could be a straight line with slope of almost zero, showing almost no time difference between the masses.

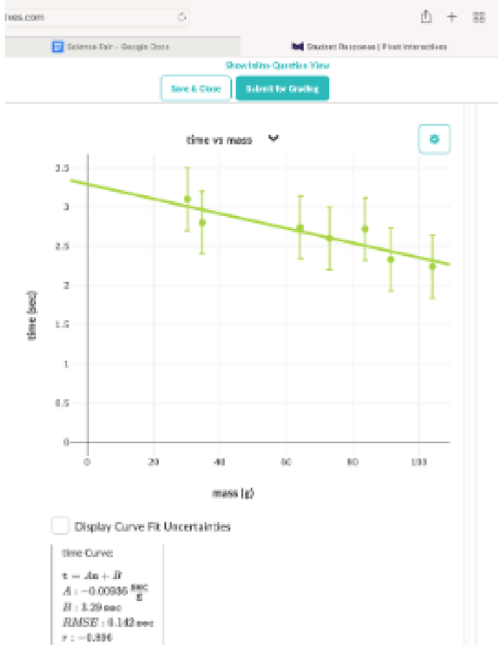
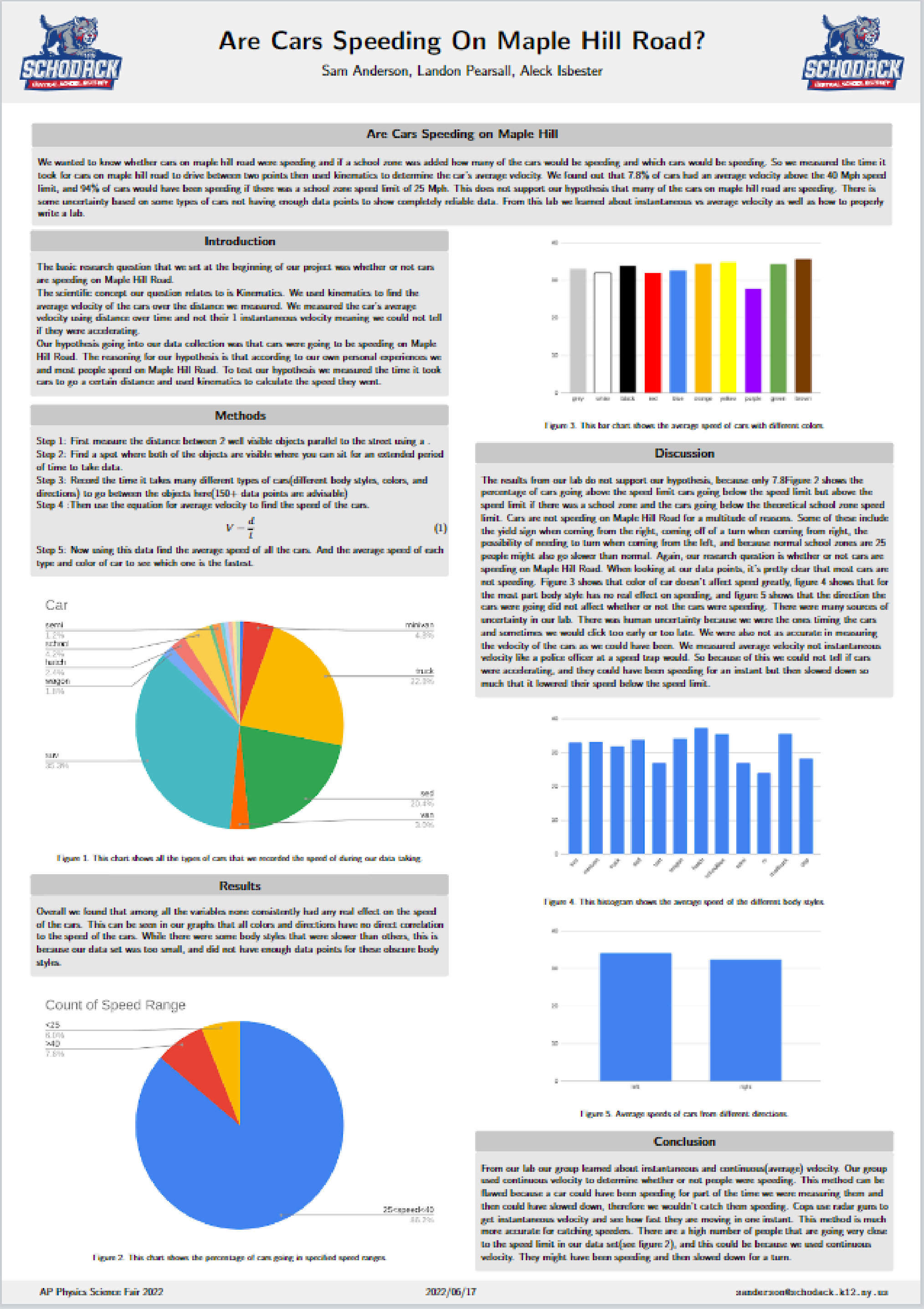


FIG. 1. Trial 2 Graph

The results of our lab show that the mass of a balloon does not affect the flight time. Our visuals demonstrate that our independent variable, mass, does not affect the dependent variable, time. The graph shows that the slope is almost zero supporting that the mass had no effect.

* permanent address: 1216 Maple Hill Road, Castleton-on-Hudson, NY, USA

POSTER EXAMPLE



Are Cars Speeding On Maple Hill Road?

Sam Anderson, Landon Pearsall, Aleck Isbester

Are Cars Speeding on Maple Hill

We wanted to know whether cars on maple hill road were speeding and if a school zone was added how many of the cars would be speeding and which cars would be speeding. So we measured the time it took for cars on maple hill road to drive between two points then used kinematics to determine the car's average velocity. We found out that 7.8% of cars had an average velocity above the 40 Mph speed limit, and 94% of cars would have been speeding if there was a school zone speed limit of 25 Mph. This does not support our hypothesis that many of the cars on maple hill road are speeding. There is some uncertainty based on some types of cars not having enough data points to show completely reliable data. From this lab we learned about instantaneous vs average velocity as well as how to properly write a lab.

Introduction

The basic research question that we set at the beginning of our project was whether or not cars are speeding on Maple Hill Road.
The scientific concept our question relates to is Kinematics. We used kinematics to find the average velocity of the cars over the distance we measured. We measured the car's average velocity using distance over time and not their 1 instantaneous velocity meaning we could not tell if they were accelerating.
Our hypothesis going into our data collection was that cars were going to be speeding on Maple Hill Road. The reasoning for our hypothesis is that according to our own personal experiences we and most people speed on Maple Hill Road. To test our hypothesis we measured the time it took cars to go a certain distance and used kinematics to calculate the speed they went.

Methods

Step 1: First measure the distance between 2 well visible objects parallel to the street using a .
Step 2: Find a spot where both of the objects are visible where you can sit for an extended period of time to take data.
Step 3: Record the time it takes many different types of cars(different body styles, colors, and directions) to go between the objects here(150+ data points are advisable)
Step 4 :Then use the equation for average velocity to find the speed of the cars.

$$V = \frac{d}{t} \qquad (1)$$

Step 5: Now using this data find the average speed of all the cars. And the average speed of each type and color of car to see which one is the fastest.

Figure 1. This chart shows all the types of cars that we recorded the speed of during our data taking.

Results

Overall we found that among all the variables none consistently had any real effect on the speed of the cars. This can be seen in our graphs that all colors and directions have no direct correlation to the speed of the cars. While there were some body styles that were slower than others, this is because our data set was too small, and did not have enough data points for these obscure body styles.

Figure 2. This chart shows the percentage of cars going in specified speed ranges.

Figure 3. This bar chart shows the average speed of cars with different colors.

Discussion

The results from our lab do not support our hypothesis, because only 7.8Figure 2 shows the percentage of cars going above the speed limit cars going below the speed limit but above the speed limit if there was a school zone and the cars going below the theoretical school zone speed limit. Cars are not speeding on Maple Hill Road for a multitude of reasons. Some of those include the yield sign when coming from the right, coming off of a turn when coming from right, the possibility of needing to turn when coming from the left, and because normal school zones are 25 people might also go slower than normal. Again, our research question is whether or not cars are speeding on Maple Hill Road. When looking at our data points, it's pretty clear that most cars are not speeding. Figure 3 shows that color of car doesn't affect speed greatly, figure 4 shows that for the most part body style has no real effect on speeding, and figure 5 shows that the direction the cars were going did not affect whether or not the cars were speeding. There were many sources of uncertainty in our lab. There was human uncertainty because we were the ones timing the cars and sometimes we would click too early or too late. We were also not as accurate in measuring the velocity of the cars as we could have been. We measured average velocity not instantaneous velocity like a police officer at a speed trap would. So because of this we could not tell if cars were accelerating, and they could have been speeding for an instant but then slowed down so much that it lowered their speed below the speed limit.

Figure 4. This histogram shows the average speed of the different body styles.

Figure 5. Average speeds of cars from different directions.

Conclusion

From our lab our group learned about instantaneous and continuous(average) velocity. Our group used continuous velocity to determine whether or not people were speeding. This method can be flawed because a car could have been speeding for part of the time we were measuring them and then could have slowed down, therefore we wouldn't catch them speeding. Cops use radar guns to get instantaneous velocity and see how fast they are moving in one instant. This method is much more accurate for catching speeders. There are a high number of people that are going very close to the speed limit in our data set(see figure 2), and this could be because we used continuous velocity. They might have been speeding and then slowed down for a turn.

AP Physics Science Fair 2022 2022/06/17 sanderson@schodack.k12.ny.us

DAY 4 - EXPERIMENTDAL DESIGN + RESEARCH

❓ of the 📅: ***If you were ruler of your own country what would be the first law you would introduce?***

1. ✅ Finish Research
2. ✅ Finish Experimental Design
3. 🚧 Start Collecting Data
   - Build Experimental Devices
   - Set up data tables
   - Organize Necessary Equipment
   - Etc

DAY 5 - START EXPERIMENTING

❓ of the 📅: What three items would you take with you on a deserted island?

📋 AGENDA

1. Set up your experiment
2. Start Taking Data

🎯: WEEK GOAL: COMPLETE DATA COLLECTION

DAY 6 – COLLECTING DATA

📋 AGENDA

1. Collect Data
2. Analyze Data

🎯 WEEK GOAL: COMPLETE DATA COLLECTION

DAY 7 - FINISH DATA COLLECTION

❓ of the 📅: **If you suddenly became a giant, what would be the biggest inconvenience?**

📋 AGENDA

1. Finish Collecting Data
2. Determine how to analyze data dn what figures you will make (graphs, charts, visuals, etc)
3. Start Making any necessary lab report figures, (i.e. lab set up, results, diagrams, etc)

🎯 WEEK GOAL:

🥅 Complete Data Collection

DAY 8 – DATA ANALYSIS

❓ of the 📅: What did you do over your long weekend?

📋 AGENDA

1. Finish Collecting Data
2. Determine how to analyze data dn what figures you will make (graphs, charts, visuals, etc)
3. Start Making any necessary lab report figures, (i.e. lab set up, results, diagrams, etc)

🎯 WEEK GOAL:

🥅 Complete Data Analysis and

🥅 Start Writing Lab 📝

Day 9 - Writing Your Lab 📝

❓ of the 📅: If you could share a meal with any 4 individuals, living or dead, who would they be?

📋 Agenda

1. Discussion on Writing Lab with LabWrite
2. Start writing lab in Google Docs - do not worry about adding in any images for your graphs. You will do that with Overleaf

🎯 Week Goal:

🥅 Start Writing Lab 📝 (finish by Wednesday)

DAY 10 - WRITING WITH $\LaTeX$

❓ of the 📅: **What form of public transportation do you prefer? (air, boat, train, bus, car, etc.)?**

📋 AGENDA

0. Letters of Rec
1. What is $\LaTeX$? Why do we use it?
2. Finish Writing Lab Report
3. Start Tranferring to Overleaf

🎯 WEEK GOAL:

🥅 Write Lab Report 📝 (finish by Wednesday)

Day 11 - Writing with $\LaTeX$

❓ of the 📅: Do you have a regular summer vacation spot? If so where?

📋 Agenda

0. Letters of Rec
1. What is $\LaTeX$? Why do we use it?
2. Finish Writing Lab Report
3. Start Tranferring to Overleaf

🎯 Week Goal:

🥅 Write Lab Report 📝 (finish by Wednesday)

What is $\LaTeX$?

- Type setting program for professional documnets, made for scientific and mathematical documents
- Plain text file that interspersed with LaTeX commands and complied with a *TeX engine*
  - Sort of like a computer program
  - Converts commands into a PDF File
- Not WYSIWYG like Microsoft Word or Google Docs

Why use $\LaTeX$?

- support for typesetting extremely complex mathematics, tables and technical content for the physical sciences;
- facilities for footnotes, cross-referencing and management of bibliographies;
- ease of producing complicated, or tedious, document elements such as indexes, glossaries, table of contents, lists of figures;
- being highly customizable for bespoke document production due to its intrinsic programmability and extensibility through thousands of free add-on packages.

MAKING YOUR FIRST DOCUMENT

```latex
\documentclass{article}
\begin{document}
First document. This is a simple example, with no
extra parameters or packages included.
\end{document}
```

ADD IN TITLES

```latex
\documentclass[12pt, letterpaper]{article}
\title{My first LaTeX document}
\author{Hubert Farnsworth}
\date{August 2022}
\begin{document}
\maketitle
We have now added a title, author and
date to our first \LaTeX{} document!
\end{document}
```

My first LaTeX document

Hubert Farnsworth*

August 2022

We have now added a title, author and date to our first LaTeX document!

*Funded by the Overleaf team.

1

BOLD, *ITALICS*, UNDERLINE

```
Some of the \textbf{greatest}
discoveries in \underline{science}
were made by \textbf{\textit{accident}}.
```

ADD FIGURES

```latex
\documentclass{article}
\usepackage{graphicx}
\graphicspath{{images/}}

\begin{document}

\begin{figure}[h]
    \centering
    \includegraphics[width=0.75\textwidth]{mesh}
    \caption{A nice plot.}
    \label{fig:mesh1}
\end{figure}

As you can see in figure \ref{fig:mesh1},
the function grows near the origin. This
example is on page \pageref{fig:mesh1}.

\end{document}
```

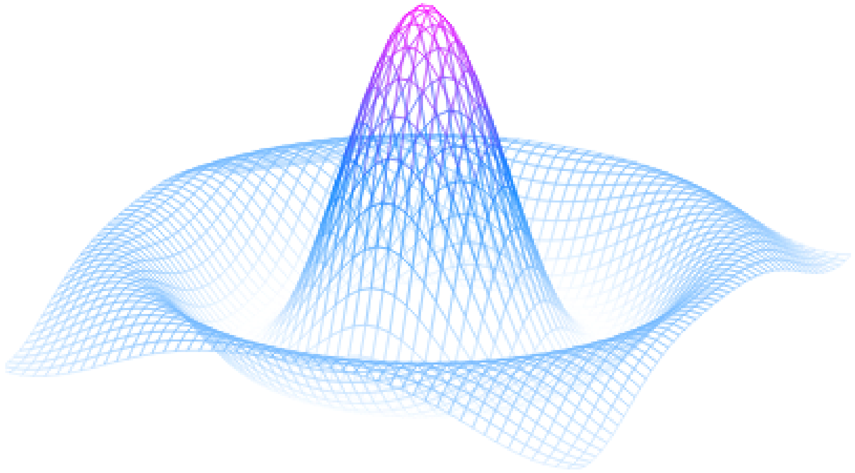


Figure 1: A nice plot.

As you can see in figure 1, the function grows near the origin. This example is on page 1.

Adding Math

Inline Math

In in the middle of a block of text:

```latex
\documentclass[12pt, letterpaper]{article}
\begin{document}
In physics, the mass-energy equivalence is stated
by the equation $E=mc^2$, discovered in 1905 by Albert Einstein.
\end{document}
```

In physics, the mass-energy equivalence is stated by the equation $E = mc^2$

ADDING MATH

Display Math

```
\documentclass[12pt, letterpaper]{article}
\begin{document}
The mass-energy equivalence is described by the famous equation \[ E=mc^2 \] discovered in 1905 by Albert Einstein.

In natural units ($c = 1$), the formula expresses the identity
\begin{equation}
E=m
\end{equation}
\end{document}
```

The mass-energy equivalence is described by the famous equation

$$E = mc^2$$

discovered in 1905 by Albert Einstein.

In natural units ($c = 1$), the formula expresses the identity

$$E = m \tag{1}$$

Symbols	and	Code	
αA `\alpha A`	νN `\nu N`	ηH `\eta H`	τT `\tau T`
βB `\beta B`	$\xi \Xi$ `\xi \Xi`	ζZ `\zeta Z`	$\sigma \Sigma$ `\sigma \Sigma`
$\gamma \Gamma$ `\gamma \Gamma`	$o O$ `o O`	ϵE `\epsilon E`	$\rho \varrho P$ `\rho \varrho P`
$\delta \Delta$ `\delta $\Delta`	$\pi \Pi$ `\pi \Pi`	χX `\chi X`	$\upsilon \Upsilon$ `\upsilon \Upsilon`
ιI `\iota I`	$\phi \Phi$ `\phi \Phi`	κK `\kappa K`	$\theta \Theta$ `\theta \Theta`
$\lambda \Lambda$ `\lambda \Lambda`	$\psi \Psi$ `\psi \Psi`	μM `\mu M`	$\omega \Omega$ `\omega \Omega`

MORE MATH THINGS 🧮

- for sub and superscripts we use _ and ^
  - $E = mc^2$ `E = mc^2`
  - F_N `F_N` or F_{normal} `F_{normal}`
- Fractions
  - $a = \frac{\Sigma \vec{F}}{m}$ `a = \frac{\Sigma \vec{F}}{m}` `\frac{num}{dem}`
- Trig:
  - $\sin\theta \cos\theta \tan\theta$ `\sin\theta \cos\theta \tan\theta`

DAY 12 - FINISH LAB REPORT

❓ of the 📅: What is your ideal burger 🍔 (or veggie burger)?

📋 AGENDA

1. Finish Writing Lab Report
2. Transfer to Latex & Overleaf

🎯 WEEK GOAL:

🥅 Write Lab Report 📝 (finish by Wednesday)

Day 13 – Start Poster

❓ of the 📅:

📋 Agenda

1. Finish Writing Lab Report
2. Transfer to Latex & Overleaf
3. Start Poster:
    - Find Template on Overleaf
    - OR use canva.com

🎯 Week Goal:

🥅 Finish Lab Report 📝

🥅 Start Poster

POSTER DAY

❓ of the 📅: Summer time! 🏝️ or ⛰️ vacation? What do you want to learn about yourself this summer? What are yo most looking forward to this summer?

Poster Procedures 📋:

- **One member** of your group should be at your poster at **all times** (exception: if you worked alone). **Rotate** who this is.
- **Visit all posters** and ask presenter questions about their project
  - "*What do you learn*" or "*What would you change if you were to do this again?*" or "*What is your most interesting fining?*"
  - Do no crowd any poster, spread out, go to posters with fewer people and rotate around the room
- Have some snacks